CATV TRUNK AMPLIFIER, UPWARD SIGNAL AMPLIFIER, AND BI-DIRECTIONAL CATV SYSTEM

BACKGROUND OF THE INVENTION

i) Technical Field of the Invention

This invention relates to a CATV amplifier, provided on a transmission line from a center equipment of a bi-directional CATV system to terminal devices, and respectively amplifying upward signal and downward signal bi-directionally flowing through the transmission line.

ii) Description of the Related Art

Conventional CATV amplifiers are provided on a trunk connected to a center equipment, and branch lines branching from the trunk in a bi-directional CATV system. They amplify bi-directional signals flowing through the transmission lines. Such CATV amplifier (specifically, CATV trunk amplifier, CATV trunk bridger amplifier, CATV extender amplifier and CATV bridger amplifier provided on the branch lines branching from the trunk) comprises a downward amplifying circuit for amplifying downward signal transmitted from the center equipment to terminal devices, and an upward amplifying circuit for amplifying upward signal transmitted from the terminal devices to the center equipment.

In recent years, not only a conventional frequency band

(for example, ranging from 5 to 42MHz) lower than that of the downward signal (for example, ranging from 54 to 722MHz) but also a frequency band (for example, ranging from 770 to 890MHz) higher than that of the downward signal are set for frequency bands of upward signals in order to increase the information amount transmitted from the terminal devices to the center equipment. Accordingly, a bi-directional CATV system using these two types of frequency bands to transmit a lot more upward signal has been proposed.

A CATV amplifier used in such system requires to amplify upward signals in different frequency bands. Therefore, as disclosed in the Unexamined Japanese Patent Publication No. 2-127824, for example, an upward L signal path for passing low-frequency upward signal (hereinafter, referred to as upward L signal) and an upward H and downward signal path for passing high-frequency upward signal (hereinafter, referred to as upward H signal) and downward signal are formed by use of a pair of directional wave filters connected to input and output terminals for transmission signals connected to transmission lines on the center equipment side and on the terminal device side, respectively. Then, an upward H signal path for passing the upward H signal and a downward signal path for passing the downward signal are formed by use of a pair of directional wave filters arranged at both ends of the upward H and downward signal path. Lastly, amplifying circuits for amplifying each

signal (upward L signal, upward H signal, downward signal) are provided on these paths (upward L signal path, upward H signal path, downward signal path).

However, in the conventional CATV amplifier constituted as above, the upward H signal, of which transmission loss in the transmission line grows the largest in these three types of transmission signals flowing through the transmission line of the bi-directional CATV system, has to pass through two directional wave filters before being inputted to the amplifying circuit (hereinafter, referred to as upward H amplifying circuit). In addition, the upward H signal after amplified by the upward H amplifying circuit also has to pass through two directional wave filters. As a result, there is a problem that the transmission loss of the upward H signal in the conventional CATV amplifier grows twice as large as that of the upward L signal, and a CN ratio (carrier-to-noise ratio) of the upward H signal is lowered.

Furthermore, it is necessary to increase the gain of the upward H amplifying circuit in order to compensate the transmission loss of the upward H signal and secure the CN ratio. For that purpose, power supply to the upward H amplifying circuit has to be increased, and thus, there arises another problem that power consumption of the whole CATV amplifier is also increased.

Specifically, since the transmission loss of the upward H

signal is larger than that of the other transmission signals (downward signal and upward L signal), it is necessary to set the gain of the upward H amplifying circuit larger than that of the other amplifying circuits (downward amplifying circuit and upward L amplifying circuit) for amplifying the other transmission signals. In the above-described conventional CATV amplifier, the transmission loss generated when the upward H signal passes through a passing path in the amplifier becomes larger than that of the upward L signal by two directional wave filters. Therefore, the gain of the upward H amplifying circuit has to be made larger than that of the other amplifying circuits.

In order to accomplish the above task, the gain of transistors for amplifying signals, constituting the upward H amplifying circuit, has to be made larger than that of transistors for the other amplifying circuits, or the connection number of the transistors has to be set larger than that of the other amplifying circuits. Then, the energy to be supplied to the upward H amplifying circuit has to be also set larger than that of the other amplifying circuits, and accordingly, the power consumption of the whole CATV amplifier is also made increased.

Furthermore, as the power consumption of the CATV amplifier is increased, distortion by hum modulation generated in the CATV amplifier grows large. Therefore, in a general bi-directional CATV system supplying power to a plurality of CATV

amplifiers via transmission lines from a power unit, there is another problem that the distortion by hum modulation cannot be ignored.

Specifically, in the bi-directional CATV system, a power unit transforming commercial power of 50Hz or 60Hz to generate alternating current power signals of tens of V is provided one per several CATV amplifiers, and the alternating current power signals generated by this power unit are supplied to each CATV amplifier via the transmission line. The distortion by hum modulation grows large as the energy supplied to the internal amplifying circuit of each CATV amplifier is increased, and also grows large in the whole system as the cascade number of the CATV amplifiers is increased. Therefore, when power consumption per CATV amplifier increases as above, the distortion by hum modulation generated in the whole system cannot be ignored.

SUMMARY OF THE INVENTION

One object of the present invention is, in a bi-directional CATV system transmitting not only downward signal and upward L signal with a frequency lower than that of the downward signal but also upward H signal with a frequency higher than that of the downward signal, to reduce transmission loss of the upward H signal at a CATV amplifier so that a CN ratio and distortion by hum modulation in the whole system can

be improved.

In order to attain the above object, the first aspect of this invention provides a CATV amplifier, in which out of transmission signals flowing through transmission line of a bi-directional CATV system, downward signal inputted to a first terminal from the transmission line on a center equipment side is inputted to a downward amplifying circuit via a first filter and a second filter; upward L signal inputted from the transmission line on a terminal device side to a second terminal is inputted to an upward L amplifying circuit via the first filter and a third filter; and upward H signal inputted also from the transmission line on the terminal device side to the second terminal is inputted to an upward H amplifying circuit via a fourth filter.

Additionally, in the signals amplified at each of the amplifying circuits, the downward signal amplified at the downward amplifying circuit is transmitted to the transmission line on the terminal device side via the second filter, the first filter and the second terminal; the upward L signal amplified at the upward L amplifying circuit is transmitted to the transmission line on the center equipment side via the third filter, the first filter and the first terminal; and the upward H signal amplified at the upward H amplifying circuit is transmitted to the transmission line on the center equipment side via the fourth filter and the first terminal.

According to the CATV amplifier of the present invention,

in three types of transmission signals flowing through the transmission line of the bi-directional CATV system, the upward H signal of which transmission loss in the transmission line grows most significantly passes through only the fourth filters provided in the former and latter stages of the upward H amplifying circuit. Therefore, the passing count of the filters (aforementioned directional wave filters) can be reduced from four to two, compared to the case of the aforementioned conventional CATV amplifier.

According to the first aspect of the present invention, the transmission loss of the upward H signal in the CATV amplifier can be reduced approximately in half compared to that of the conventional CATV amplifier and lowering of the CN ratio of the upward H signal is avoided. Also, the gain of the upward H amplifying circuit can be smaller than that of the conventional one, and as the power consumption at the CATV amplifier is reduced, generation of distortion by hum modulation can be controlled.

The effect of reducing the power consumption and the distortion by hum modulation is quite small for a single CATV amplifier. However, the bi-directional CATV system adopting the CATV amplifier of the present invention comprises multiple cascade connections of the CATV amplifiers on the transmission line. Therefore, the second aspect of the present invention provides a bi-directional CATV system using the CATV

amplifiers of the first aspect of the present invention, which can effectively reduce the power consumption and the distortion by hum modulation in the whole bi-directional CATV system.

The third aspect of the present invention is to provide an upward signal amplifier externally attached to the existing CATV amplifier capable of amplifying both downward signals and upward L signal with a frequency lower than that of the downward signal to constitute the CATV amplifier of the first aspect of the invention.

The upward signal amplifier of the present invention comprises a third terminal and a fourth terminal for connecting the upward signal amplifier to the transmission line on the center equipment side and on the terminal device side respectively; a fifth terminal and a sixth terminal for connecting the upward signal amplifier to a terminal for inputting the downward signal and outputting the upward L signal and a terminal for inputting the upward L signal and outputting the downward signal, respectively, of the existing CATV amplifier; and an upward H amplifying circuit for amplifying upward H signal with a frequency higher than the downward signal.

When each of the above terminals is connected to a corresponding transmission line or terminal of the CATV amplifier, the downward signal transmitted via the transmission line on the center equipment side is inputted to the upward signal amplifier via the third terminal to be outputted to the

terminal for inputting the downward signal and outputting the upward L signal of the CATV amplifier via the first filter and the fifth terminal. As a result, the downward signal is amplified at the CATV amplifier and outputted from the terminal for inputting the upward L signal and outputting the downward signal of the CATV amplifier. The downward signal after the amplification is again inputted to the upward signal amplifier via the sixth terminal to be transmitted to the transmission line on the terminal device side via the first filter and the fourth terminal.

The upward L signal transmitted via the transmission line on the terminal device side is, after inputted to the upward signal amplifier via the fourth terminal, outputted to the terminal for inputting the upward L signal and outputting the downward signal of the CATV amplifier via the first filter and the sixth terminal. As a result, the upward L signal, as well as the downward signal, is amplified at the CATV amplifier, and outputted from the terminal for inputting the downward signal and outputting the upward L signal of the CATV amplifier. The upward L signal is again inputted to the upward signal amplifier via the fifth terminal, and later outputted to the transmission line on the center equipment side via the first filter and the third terminal.

In the mean time, the upward H signal transmitted via the transmission line on the terminal device side is inputted to

the upward H amplifying circuit in the upward signal amplifier via the fourth terminal and the fourth filter to be amplified. Then, the upward H signal after the amplification is outputted to the transmission line on the center equipment side via the fourth filter and the third terminal.

According to the upward signal amplifier of the third aspect of the present invention, in the bi-directional CATV system, it is possible not only to amplify the upward H signal transmitted from the terminal device side at the upward H amplifying circuit and transmit it to the center equipment side, but also to output the downward signal transmitted from the center equipment side and the upward L signal transmitted from the terminal device side, respectively, to the existing CATV amplifier to amplify and transmit them to the terminal device side and to the center equipment side, respectively. According to the upward signal amplifier of the third aspect of the present invention being externally attached to the existing CATV amplifier capable of amplifying the downward signal and the upward L signal, it is possible to constitute a CATV amplifier capable of amplifying the downward signal, upward L signal and upward H signal, respectively.

In the upward signal amplifier of the third aspect of the present invention, the upward H signal with the highest frequency in three types of transmission signals passes through only the fourth filters provided at the former and latter stages of

the upward H amplifying circuit, just like in the CATV amplifier of the first aspect of the present invention. Accordingly, the upward signal amplifier of the third aspect of the present invention, if externally attached to the existing CATV amplifier, can realize a CATV amplifier having the same effect as the CATV amplifier of the first aspect of the present invention. For example, it is quite advantageous in case that the existing bi-directional CATV system capable of transmitting downward signal and upward L signal is transformed to a system capable of transmitting also upward H signal.

When the CATV amplifier of the first aspect of the present invention is constituted with the upward signal amplifier being externally attached to the existing CATV amplifier, power supply is necessary not only to the amplifiers (downward amplifying circuit and upward L amplifying circuit) in the existing amplifier, but also to the upward H amplifying circuit in the upward signal amplifier.

In the existing CATV amplifier, there is generally provided a power supply circuit generating power voltage for driving the amplifying circuits upon receipt of alternating current power signals transmitted via the transmission line. Therefore, it is possible to provide a similar power supply circuit in the upward signal amplifier. However, in order to supply the alternating current power signals transmitted via the transmission line to the power supply circuit in each of the

amplifiers, if the alternating current power signals are separated from the other transmission signals using a power separation filter provided in the upward signal amplifier, and the separated alternating current power signals are supplied to the power supply circuits in each of the amplifiers, for example, then the amount of the current flowing through the power separation filter becomes the amount of the current consumed at all three types of amplifying circuits, and distortion by hum modulation generated in each of the amplifiers grows large.

To prevent the above from happening, the fourth aspect of the present invention provides, in the upward signal amplifier, a pair of power separation filters arranged at least either between the third terminal and the first and the fourth filters, or between the fourth terminal and the first and the fourth filters, for separating alternating current power signals for power supply, transmitted from an external power unit to the third terminal or the fourth terminal via transmission line, from each transmission signal; and to the upward H amplifying circuit, power supply is conducted from the power supply circuit generating power voltage upon receipt of the alternating current power signals separated at one of the power separation filters, and to the existing CATV amplifier connected via the fifth terminal and the sixth terminal, the alternating current power signals separated at the other power separation filter is supplied via the fifth terminal or the sixth terminal.

In this manner, the amount of the current flowing through each power separation filter can be restricted to the amount of the current corresponding to the power consumption at the upward H amplifying circuit and the power consumption at the existing CATV amplifier (particularly, downward amplifying circuit and upward L amplifying circuit) respectively, and the distortion by hum modulation generated by the increase of the amount of the current can be controlled.

When the alternating current power signals are transmitted via the transmission line on the center equipment side, the above pair of power separation filters can be provided between the third terminal and the first and the fourth filters. When the alternating current power signals are transmitted via the transmission line on the terminal device side, they can be provided between the fourth terminal and the first and the fourth filters. The pair of power separation filters can also be provided both between the third terminal and the first and the fourth filters and between the fourth terminal and the first and the fourth filters, so that when the alternating current power signals are transmitted via the transmission line on the center equipment side, the pair of power separation filters provided between the third terminal and the first and the fourth filters can be operated, and when the alternating current power signals are transmitted via the transmission line on the terminal device side, the pair of power separation filters provided between the

fourth terminal and the first and the fourth filters can be operated.

The technique of reducing hum modulation by providing a pair of power separation filters, that is, supplying the alternating current power signals separated at one of the power separation filters to the upward H amplifying circuit and supplying the alternating current power signals separated at the other of the power separation filters to the downward amplifying circuit and the upward L amplifying circuit, can be applied to a sole CATV amplifier of the first aspect of the present invention.

Since the above power separation filters separate the low-frequency alternating current power signals (generally with 50Hz or 60Hz which is the same frequency as that of commercial power) from the high-frequency transmission signals, they comprise condensers for passing the transmission signals and choke coils for passing the alternating current power signals. If the fourth filters are constituted of a high pass filter capable of cutting off the alternating current power signals and the first filters are constituted of a low pass filter capable of passing the alternating current power signals, these filters can be used for the power separation filters.

An upward signal amplifier of the fifth aspect of the present invention is provided with a pair of separation filters, one of which for supplying the alternating current power signals to the power supply circuit in the upward signal amplifier

constituted of the fourth filter and a choke coil connecting between at least either the third terminal or the fourth terminal and the power supply circuit, and the other of which for supplying the alternating current power signals to the existing CATV amplifier which is a low pass filter constituting the first filter.

Accordingly, there is no need to provide a pair of exclusive filter circuits comprising a condenser and a choke coil as a pair of power separation filters, and thus the constitution of the upward signal amplifier is simplified.

The sixth aspect of the present invention provides a bi-directional CATV system comprising a plurality of existing CATV amplifiers, to which the above upward signal amplifier is added, being arranged on transmission line between a center equipment and terminal devices. According to this bi-directional CATV system, it is possible to build a bi-directional CATV system capable of transmitting upward H signal in addition to the downward signal and the upward L signal, using the existing CATV amplifier capable of amplifying downward signal and upward L signal. Thus, it is economical compared to the case of building the bi-directional CATV system in the second aspect of the invention which utilizes the CATV amplifier in the first aspect of the present invention.

Additionally, if the upward signal amplifier in the fourth or the fifth aspect of the present invention is used upon building

this bi-directional CATV system, it is possible to reduce distortion by hum modulation generated in each CATV amplifier provided on the transmission line and thus to restrict hum modulation in the whole system.

Furthermore, the larger the connection number of the CATV amplifiers cascaded on the transmission line is, the worse the hum modulation in the whole bi-directional CATV system becomes. Accordingly, when a bi-directional CATV system is built using the upward signal amplifier (and CATV amplifier) comprising a pair of power separation filters, one for the upward H amplifying circuit and the other for the downward amplifying circuit and the upward L amplifying circuit, it is possible to increase the number of the CATV amplifiers compared to the case of the bi-directional CATV system using the CATV amplifiers comprising one power separation filter common to each of the amplifying circuits, and thus it is possible to build a large-scale system.

Specifically, the number of the CATV amplifiers to hold down the hum modulation of the whole system to a rated value depends on how large the distortion by hum modulation generated in each of the CATV amplifiers is. Thus, when a bi-directional CATV system capable of transmitting the upward H signal is built using the upward signal amplifier in the fourth or the fifth aspect of the present invention, it is possible to extend the transmission line or to increase the number of subscriber

terminal devices by increasing the number of the CATV amplifiers capable of being cascaded on the transmission line.

The seventh aspect of the present invention provides a bi-directional CATV system using the conventional CATV amplifier to which the upward signal amplifier is externally attached as in the sixth aspect of the present invention, in which, in a plurality of CATV amplifiers connected via the upward signal amplifier to the transmission line, the fourth terminal and the sixth terminal of the upward signal amplifier provided for a first CATV amplifier located at a predetermined distance from a center equipment is terminated at the characteristic impedance of the transmission line; a terminal for inputting upward L signal and outputting downward signal of the first CATV amplifier is directly connected to a terminal for inputting the downward signal and outputting the upward L signal of a second CATV amplifier located at the next stage to the first amplifier via the transmission line; the fifth terminal of the upward signal amplifier provided for the second CATV amplifier is terminated at the characteristic impedance of the transmission line; and the third terminal of the upward signal amplifier provided for the second CATV amplifier is connected to the center equipment via an optical transmission path capable of converting electrical signal to optical signal.

In this manner, it is possible to directly transmit the upward H signal, transmitted via CATV amplifiers located closer

to the terminal device side than the second CATV amplifier, to the center equipment via the optical transmission path. Thus, confluent noises transmitted to the center equipment, synthesized on the transmission line by noises in a transmission frequency band of the upward H signal generated on the terminal device side are reduced and the accuracy of receiving the upward H signal on the center equipment side can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a diagram showing an overall constitution of a bi-directional CATV system of an embodiment, according to the present invention;

Fig. 2 is a block diagram showing a constitution of a CATV trunk amplifier (CATV extender amplifier) of an embodiment;

Fig. 3 is a block diagram showing a constitution of a CATV trunk bridger amplifier (CATV bridger amplifier) of an embodiment;

Fig. 4 is a block diagram showing a constitution of a CATV trunk amplifier (CATV extender amplifier) of a referential example different from the invention;

Fig. 5 is a block diagram showing a constitution of a separate-type CATV trunk amplifier (CATV extender amplifier)

of an embodiment;

Fig. 6 is a diagram showing an example upon constituting a bi-directional CATV system using a separate-type amplifier illustrated in Fig. 5; and

Fig. 7 is an explanatory view showing an example of other constitution of the upward H amplifier illustrated in Fig. 5.

DETAILED DESCRIPTION OF THE INVENTION

As shown in Fig. 1, a bi-directional CATV system of the present embodiment transmits downward signal in a predetermined transmission frequency band (for example, ranging from 54 to 722MHz) from a center equipment 2 to a terminal device, and also transmits upward L signal in a transmission frequency band (for example, ranging from 5 to 42MHz) lower than that of the downward signal and upward H signal in a frequency band (for example, ranging from 770 to 890MHz) higher than that of the downward signal from the terminal device to the center equipment 2, respectively.

The bi-directional CATV system comprises, as transmission line for bi-directionally transmitting the aforementioned signals between the center equipment 2 and the terminal devices on the side of subscribers of the CATV system, a trunk La connected to the center equipment 2; a plurality of first branch lines Lb branching from the trunk La via CATV trunk bridger amplifiers 6 provided on the trunk La and not-illustrated

directional couplers; a plurality of second branch lines Lc branching from the first branch lines Lb via CATV bridger amplifiers 6' provided on each first branch line Lb and not-illustrated directional couplers; and lead-in wires Ld, branching from the second branch lines Lc via tap-offs (directional couplers) 8 provided on the second branch lines Lc, and also extending to not-illustrated protectors on the subscriber side. In the present embodiment, all of these lines (transmission lines) are made of coaxial cables and their characteristic impedance is 50Ω or 75Ω.

CATV trunk amplifiers 4 for amplifying the transmission signals flowing bi-directionally through the trunk La and the aforementioned CATV trunk bridger amplifiers 6 are cascaded to the trunk La at a predetermined interval as CATV amplifiers of the present invention. CATV extender amplifiers 4' for amplifying the transmission signals flowing bi-directionally through the first branch lines Lb and the aforementioned CATV bridger amplifiers 6' are also cascaded to the first branch lines Lb at a predetermined interval as the CATV amplifiers of the present invention.

Alternating current power signals (for example, 60Hz, AC60V), which is a stepped-down commercial power, flow through the trunk La and the first branch lines Lb via power signal overlay circuits 10a and 10a'. Power units 10 and 10' for supplying power to each of the amplifiers 4, 6 and 4', 6' are

provided on the trunk La and the first branch lines Lb. The ratio of the power unit 10 (or 10') to the amplifiers 4, 6 (or 4', 6') arranged on the trunk La (or the first branch lines Lb) is one to plural (for example, eight).

Now, a constitution of each of the amplifiers 4, 6, 4', 6' provided on the trunk La and the first branch lines Lb as above is described. The CATV trunk amplifier 4 and the CATV extender amplifier 4', and the CATV trunk bridger amplifier 6 and the CATV bridger amplifier 6', respectively, are constituted in the same manner and are different only in characteristics (such as the gain) of internal amplifying circuits. Accordingly, only the constitutions of the CATV trunk amplifier 4 and the CATV trunk bridger amplifier 6 provided on the trunk La are explained and the explanation of the constitutions of the CATV extender amplifier 4' and the CATV bridger amplifier 6' provided on the first branch lines Lb are omitted.

As shown in Fig. 2, the CATV trunk amplifier 4 comprises an input terminal Tin and an output terminal Tout for connecting the transmission line (trunk La) on the center equipment 2 side and on the terminal device side, respectively.

Downward signal inputted to the input terminal Tin via the transmission line on the center equipment 2 side is inputted to a downward amplifying circuit 18 for amplifying downward signal via a power separation filter 12, a low pass filter (hereinafter, referred to as LPF) 14 and a high pass filter

(hereinafter, referred to as HPF) 16, and amplified to a predetermined level at the downward amplifying circuit 18. The downward signal after the amplification is transmitted to the output terminal Tout via a HPF 20, a LPF 22 and a power separation filter 24, and outputted to the transmission line on the terminal device side.

A cutoff frequency of the LPF 14 and LPF 22 is set to 722MHz, for example, so that the LPF 14 and LPF 22 can cut off the upward H signal and only pass the downward signal and upward L signal selectively. A cutoff frequency of the HPF 16 and HPF 20 is set to 54MHz, for example, so that the HPF 16 and HPF 20 can cut off the upward L signal and only pass the downward signal selectively.

The power separation filters 12, 24 separate the aforementioned three types of transmission signals (downward signal, upward L signal and upward H signal) from the alternating current power signals supplied from the power unit 10. Each of the power separation filters 12, 24 comprises a condenser C, one end of which is connected to the input terminal Tin or output terminal Tout to pass the above transmission signals (high-frequency signals), and a choke coil L, one end of which is connected to the input terminal Tin or output terminal Tout to pass the low-frequency alternating current power signals. The other ends of the condensers C constituting the power separation filters 12, 24 are connected to the aforementioned

LPFs 14, 22 and further to HPFs 36, 32 as described later.

Upward L signal inputted to the output terminal Tout via the transmission line on the terminal device side is inputted to an upward L amplifying circuit 28 for amplifying upward L signal via the power separation filter 24, the LPF 22 and a LPF 26, and amplified to a predetermined level at the upward L amplifying circuit 28. The upward L signal, after the amplification, is transmitted to the input terminal Tin via a LPF 30, the LPF 14 and the power separation filter 12, and outputted to the transmission line on the center equipment 2 side. A cutoff frequency of the LPF 26 and LPF 30 is set to 42MHz, for example, so that the LPF 26 and LPF 30 can cut off the downward signal and only pass the upward L signal selectively.

Upward H signal inputted to the output terminal Tout via the transmission line on the terminal device side is inputted to an upward H amplifying circuit 34 for amplifying upward H signal via the power separation filter 24 and the HPF 32, and amplified to a predetermined level at the upward H amplifying circuit 34. The upward H signal, after the amplification, is transmitted to the input terminal Tin via the HPF 36 and the power separation filter 12, and outputted from the input terminal Tin to the transmission line on the center equipment 2 side. A cutoff frequency of the HPF 32 and HPF 36 is set to 770MHz, for example, so that the HPF 32 and HPF 36 can cut off the downward signal and the upward L signal and only pass the

upward H signal selectively.

The other ends of the choke coils L of the power separation filters 12, 24 are connected to a power supply circuit (PS) 40 via switches 42, 44, and also connected to each other via a switch 46.

These switches 42, 44, 46 are provided so that a system administrator of the CATV system can manually switch the connecting state of the paths between them. For instance, when the power unit 10, supplying power to the CATV trunk amplifier 4, is located on the center equipment 2 side compared to the CATV trunk amplifier 4, the switch 42 is turned ON and the switch 44 is turned OFF to supply the alternating current power signals from the power unit 10 to the power supply circuit 40.

The switch 46 is turned ON when the power unit 10, supplying power to the CATV trunk amplifier 4, supplies power to an amplifier arranged at the farther side across the CATV trunk amplifier 4. In other words, when it is required to supply the alternating current power signals supplied from the power unit 10 to the amplifier arranged on the farther side across the CATV trunk amplifier 4, the switch 46 is turned ON and it is possible to operate the CATV trunk amplifier 4 as what is called a power passing amplifier.

The power supply circuit 40 rectifies and smoothes the alternating current power signals (for example, AC60V) supplied from the external power unit 10 to generate direct current

constant voltage (for example, DC12V). It supplies the generated direct current constant voltage to the above amplifying circuits 18, 28 and 34 as power voltage Vc so that the amplifying circuits 18, 28 and 34 can be operated.

As shown in Fig. 3, the CATV trunk bridger amplifier 6 is basically constituted the same as the CATV trunk amplifier 4 shown in Fig. 2. The CATV trunk bridger amplifier 6 is constituted by adding following circuits to the CATV trunk amplifier 4.

The CATV trunk bridger amplifier 6 comprises a branching circuit 72 for branching a part of the downward signal in the path of the downward signal from the downward amplifying circuit 18 to the HPF 20; a branching amplifying circuit 74 for amplifying the downward signal branched at the branching circuit 72; a mixing circuit 76 for mixing upward L signal, transmitted via the first branch lines Lb with upward L signal transmitted via the trunk La in the path of the upward L signal from the LPF 26 to the upward L amplifying circuit 28; and a mixing circuit 78 for mixing upward H signal, transmitted via the first branch lines Lb with upward H signal transmitted via the trunk La in the path of the upward H signal from the HPF 32 to the upward H amplifying circuit 34.

The CATV trunk bridger amplifier 6 comprises a plurality of branching terminals Tb (in the present embodiment, four branching terminals Tb1, Tb2, Tb3, Tb4) so that the plurality of

first branch lines Lb can be connected. Splitting terminals of a splitting circuit (in the present embodiment, four-way splitting circuit) 80 are connected to the branching terminals Tb1-Tb4, respectively. A common terminal of the splitting circuit 80 is connected to the mixing circuit 78 via a HPF 32' functioning the same as the aforementioned HPFs 32, 36 so that the upward H signal inputted to each of the branching terminals Tb1-Tb4 can be transmitted to the mixing circuit 78 via the branching circuit 80 and the HPF 32'.

One end of a LPF 22' functioning the same as the aforementioned LPFs 14, 22 is connected to the common terminal of the splitting circuit 80. The other end of the LPF 22' is connected to an output terminal of the branching amplifying circuit 74 via a HPF 20' functioning the same as the aforementioned HPFs 16, 20, and also connected to the mixing circuit 76 via a LPF 26' functioning the same as the aforementioned LPFs 26, 30.

Accordingly, the upward L signal inputted to each of the branching terminals Tb1-Tb4 is transmitted to the mixing circuit 76 via the splitting circuit 80, LPF 22' and LPF 26', and the downward signal amplified at the branching amplifying circuit 74 is outputted to the transmission line (first branch line Lb) on the terminal device side from each of the branching terminals Tb1-Tb4 via the HPF 20', LPF 22' and splitting circuit 80.

The power supply circuit 40 supplies the direct current

constant voltage (DC12V) not only to the downward amplifying circuit 18, upward L amplifying circuit 28 and upward H amplifying circuit 34 but also to the branching amplifying circuit 74 so that the branching amplifying circuit 74 can be operated.

As described above, in the CATV amplifier (not only CATV trunk amplifier 4 and CATV trunk bridger amplifier 6, but also CATV extender amplifier 4' and CATV bridger amplifier 6') of the present embodiment, a pair of the HPFs 32 (or 32') and 36 arranged in the former and latter stages of the upward H amplifying circuit 34 are provided as filters for extracting the upward H signal, on the path through which the highest-frequency upward H signal of all the transmission signals flowing through the transmission line (such as trunk La, first branch lines Lb) of the bi-directional CATV system passes. Accordingly, it is possible to reduce the number of filters through which the upward H signal passes by half, that is, from four to two, compared to a case of a conventional CATV amplifier.

The CATV amplifier of the present invention, thus, can reduce transmission loss of the upward H signal in each amplifier by half and prevent lowering of a CN ratio of the upward H signal.

Specifically, the conventional filters for extracting the upward H signal are constituted of two-stage filters, provided in the former and latter stages, respectively, of the upward H amplifying circuit 34. If the transmission loss of the upward H

signal in each filter is 0.5dB, the transmission loss of 2dB can be generated per one CATV amplifier with the conventional filters, because the upward H signal passes through the filters four times per one CATV amplifier. In the present embodiment, however, the upward H signal only passes through the HPF 32 (or 32') and HPF 36, so the transmission loss per one CATV amplifier becomes 1dB. Since lowering of a CN ratio per one CATV amplifier is caused by the transmission loss (0.5dB) at the input part to the upward H amplifying circuit 34, the CN ratio can be improved per a single CATV amplifier.

The effect of the improvement of CN ratio in a single CATV amplifier is extremely small, since the effect at one filter is only 0.5dB of the transmission loss. However, in the whole bi-directional CATV system, the effect of the improvement of CN ratio can be significantly large, for the plurality of the CATV amplifiers (CATV trunk amplifiers 4 and CATV trunk bridger amplifiers 6, or CATV extender amplifiers 4' and CATV bridger amplifiers 6') are cascaded to the trunk La or the first branch lines Lb as shown in Fig. 1.

Specifically, when the CATV amplifiers of the present embodiment are cascaded, the CN ratio is improved by 0.5dB of transmission loss at the first CATV amplifier (that is, amplifier located the closest to the terminal device side). The transmission loss in the output part of the CATV amplifier in the former stage is added at the next CATV amplifier in and after the

second stage. Therefore, the CN ratio is to be improved by approximately 1dB of transmission loss per one CATV amplifier in the whole bi-directional CATV system.

The CN ratio to be improved by reducing 1dB of transmission loss is 1.26 times ($10 \cdot \log(n) = 1\text{dB}$, $(n) = 1.26$). For example, in case of the bi-directional CATV system comprising 16 CATV amplifiers cascaded to the trunk La in which conventional CATV amplifiers used in the bi-directional CATV system are changed to CATV amplifiers in the present embodiment, even if four CATV amplifiers (16 amplifiers multiplied by $(1.26 - 1) = 4.16$) are further added to the bi-directional CATV system, the CN ratio in the whole system is not likely to be lowered.

Additionally, in the bi-directional CATV system, 20 or more subscriber terminal devices can be generally connected to a single CATV amplifier. Accordingly, if four CATV amplifiers can be added, over 80 subscriber terminal devices can be added.

When a bi-directional CATV system is constituted using CATV amplifiers (CATV trunk amplifiers 4, CATV trunk bridger amplifiers 6, CATV extender amplifiers 4', CATV bridger amplifiers 6') of the present embodiment, it is possible to increase the number of CATV amplifiers and build a large-scale system compared to the system using the conventional CATV amplifiers.

On the other hand, according to the CATV amplifier

(CATV trunk amplifier 4, CATV trunk bridger amplifier 6, CATV extender amplifier 4' and CATV bridger amplifier 6') of the present embodiment, transmission loss of upward H signal generated in the amplifier is improved by 1dB compared to the conventional CATV amplifier. Therefore, when a bi-directional CATV system adopting the CATV amplifier of the present embodiment is constituted on the same condition as the system adopting the conventional CATV amplifier, the gain of the upward H amplifying circuit 34, showing the largest power consumption in the CATV amplifier since it amplifies high-frequency signals, can be reduced by 1dB and the power consumption of the circuit can be limited.

According to the CATV amplifier of the present embodiment, the power consumption in the CATV amplifier is reduced, and also generation of distortion by hum modulation is restrained. The effect of reducing power consumption and distortion by hum modulation may be extremely small for a single CATV amplifier. However, in the bi-directional CATV system where such CATV amplifiers are cascaded to the transmission line (such as trunk La and the first branch lines Lb), it is possible to effectively reduce the power consumption and the hum modulation.

In the above embodiment, the HPFs 32, 36 for cutting off the downward signal and upward L signal and selectively passing the upward H signal, and the LPFs 14, 22 for cutting off

the upward H signal and selectively passing the downward signal and upward L signal are connected to the input and output terminals Tin, Tout of the CATV amplifier (CATV trunk amplifier 4, CATV trunk bridger amplifier 6, CATV extender amplifier 4' and CATV bridger amplifier 6') as directional wave filters. Thus, the number of filters passing the upward H signal in the CATV amplifier is reduced from four to two (HPFs 32, 36). To reduce the number of filters passing the upward H signal in the CATV amplifier in half, the CATV amplifier may be also constituted as a referential example shown in Fig. 4.

Fig. 4 shows a referential example of a CATV trunk amplifier 4 (and CATV extender amplifier 4') reducing the number of filters which pass the upward H signal in half in a manner different from the present invention. In this example, band passing filters (band pass filters; hereinafter, referred to as BPFs) 50, 52 for cutting off the upward L signal and upward H signal and selectively passing only the downward signal, and band eliminating filters (band eliminators; hereinafter, referred to as BEFs) 54, 58 for cutting off the downward signal and selectively passing the upward L signal and upward H signal are respectively connected to the input terminal Tin and the output terminal Tout. Then, the downward amplifying circuit 18 is provided between the BPFs 50 and 52, and a broadband upward amplifying circuit 56 for amplifying the upward L signal and upward H signal is provided between the BEFs 54 and 58.

In the CATV amplifier of this example, the upward H signal passes through two filters (BEFs 54, 58) and the same effect as the above embodiment can be achieved. However, when the CATV amplifier is constituted as in the referential example, two types of upward signals in different frequency bands have to be amplified in the common upward amplifying circuit 56. Then, there arise a problem that the upward amplifying circuit 56 has to be made broadband, or otherwise, when a directional wave filter for separating signals is constituted of the BPFs and BEFs, the designing becomes difficult compared to the case of constituting a directional wave filter for separating signals using LPFs and HPFs. Especially, in order to connect BPFs and BEFs without generating transmission loss at the connection points, a separate adjusting circuit is required. Therefore, in practice, the filter constitution of the present invention is more beneficial.

In the referential example shown in Fig. 4, power separation filters (PSF) 12, 24 are also provided between the input and output terminals Tin, Tout and each of the filters (BPFs 50, 52 and BEFs 54, 58), in the same manner as the above embodiment. As the alternating current power signals (for example, AC60V) separated in the power separation filter (PSF) 12 or 24 are supplied to the internal power supply circuit 40 via the switch 42 or 44, the power voltage Vc (for example, DC12V) is supplied to each of the above amplifying circuits 18, 56, and the

alternating current power signals are transmitted to the other CATV amplifiers arranged on the transmission line (trunk La or first branch lines Lb) on the opposite side of the external power unit 10 via the switch 46.

A CATV trunk amplifier 4 in Fig. 5 is different from the unit-type CATV trunk amplifier 4 shown in Fig. 2. It is constituted of a bi-directional amplifier 60 and an upward H amplifier 61. This is what is called separate-type CATV trunk amplifier.

The bi-directional amplifier 60 is a conventional CATV trunk amplifier (or CATV extender amplifier) generally used in the existing bi-directional CATV system which bi-directionally transmits downward signal and upward L signal. Its constitution is the same as the unit-type CATV trunk amplifier 4 shown in Fig. 2, except that the bi-directional amplifier 60 does not include the upward H amplifying circuit 34, HPFs 32 and 36, LPFs 14 and 22.

In the bi-directional amplifier 60, the downward signal inputted to the input terminal Tin from the center equipment 2 is inputted to the downward amplifying circuit 18 via the power separation filter 12 and HPF 16. After amplified to a predetermined level at the downward amplifying circuit 18, the downward signal is transmitted to the output terminal Tout via the HPF 20 and the power separation filter 24, and then outputted to the terminal device from the output terminal Tout.

The upward L signal inputted to the output terminal Tout from the terminal device is inputted to the upward L amplifying circuit 28 via the power separation filter 24 and the LPF 26. After amplified to a predetermined level at the upward L amplifying circuit 28, the upward L signal is transmitted to the input terminal Tin via the LPF 30 and the power separation filter 12, and then outputted to the center equipment 2 from the input terminal Tin.

The alternating current power signals inputted to the input terminal Tin or the output terminal Tout from the center equipment 2 side or the terminal device side are, after separated from the other transmission signals (in this case, downward signal and upward L signal) at the power separation filter (PSF) 12 or 24, inputted to the power supply circuit 40 via the switch 42 or 44. If the switch 46 is ON, the alternating current power signals are further outputted to the outside via the bi-directional amplifier 60 from the terminal on the opposite side to the terminal to which the alternating current power signals are inputted.

The upward H amplifier 61 comprises an input terminal T1 and an output terminal T2 for connecting the upward H amplifier 61 to the transmission line (trunk La) on the center equipment 2 side and on the terminal device side, respectively, connection terminals T3 and T4 for connecting the upward H amplifier 61 to the input terminal Tin and the output terminal

Tout of the bi-directional amplifier 60, respectively, and the upward H amplifying circuit 34.

The input terminal T1 and the output terminal T2 are respectively connected to ends of the HPFs 36 and 32 and to ends of the LPFs 14 and 22 via the power separation filters 62 and 64. The other ends of the HPFs 36 and 32 are respectively connected to the output terminal and the input terminal of the upward H amplifying circuit 34, and the other ends of the LPFs 14 and 22 are respectively connected to the connection terminals T3 and T4 to the bi-directional amplifier 60 via the power separation filters 62 and 64.

The power separation filters 62 and 64 are provided to separate the alternating current power signals inputted to the input terminal T1 or the output terminal T2 via the transmission line (trunk La) on the center equipment 2 side or on the terminal device side from the power unit 10. They separate the alternating current power signals from the transmission signals (downward signal, upward L signal, upward H signal), and supply the alternating current power signals to the power supply circuit 40' inside the upward H amplifier 61 and the power supply circuit 40 in the bi-directional amplifier 60, respectively.

Each of the power separation filters 62 and 64 comprises a condenser C1, one end of which being respectively connected to the input or output terminal T1, T2 and the other end of which being respectively connected to the connection points between

the HPF 36 and the LPF 14 or between the HPF 32 and the LPF 22, so that each of the above transmission signals can be passed to the HPFs 36, 32 and LPFs 14, 22; a choke coil L1, one end of which being connected to the input or output terminal T1, T2, and the other end of which being connected to the power supply circuit 40' via the switch 42' or the switch 44' so that the alternating current power signals can be supplied to the internal power supply circuit 40'; a choke coil L2, one end of which being connected to the input or output terminal T1, T2, and the other end being respectively connected to the connection terminal T3 or T4 so that the alternating current power signals can be transmitted to the bi-directional amplifier 60; and a condenser C2, provided between the LPFs 14, 22 and the connection terminals T3, T4 and passing the downward signal and the upward L signal.

Specifically, each of the power separation filters 62 and 64 respectively comprises the choke coil L1 for supplying the alternating current power signals to the internal power supply circuit 40' and the choke coil L2 for supplying the alternating current power signals to the power supply circuit 40 of the bi-directional amplifier 60.

Additionally, the upward H amplifier 61 comprises, as well as the bi-directional amplifier 60, not only switches 42' and 44' turned on/off by external operations to supply the alternating current power signals separated via the choke coil L1 of the

power separation filter 62 or 64 to the internal power supply circuit 40', but also a switch 46' turned on/off for connecting or separating the connection points between the switches 42', 44' and the choke coils L1 so that the alternating current power signals can be supplied to the other amplifiers provided on the transmission line (trunk La) on the opposite side to the power unit 10.

The upward H amplifier 61 constituted as above is externally attached to the bi-directional amplifier 60 with the connection terminals T3 and T4 respectively connected to the input terminal Tin and the output terminal Tout of the bi-directional amplifier 60 via the coaxial cable Le. The transmission line (trunk La) on the center equipment 2 side is connected to the input terminal T1, and the transmission line (trunk La) on the terminal device side is connected to the output terminal T2.

According to the CATV trunk amplifier 4 (or CATV extender amplifier 4') in which the upward H amplifier 61 is externally attached to the conventional bi-directional amplifier 60, the upward H signal transmitted from the terminal device side is selectively inputted to the upward H amplifying circuit 34 via the HPF 32, and after amplified at the upward H amplifying circuit 34, the upward H signal is outputted to the transmission line (trunk La) on the center equipment side from the input terminal T1 via the HPF 36.

Therefore, in the CATV trunk amplifier 4 (or CATV extender amplifier 4') shown in Fig. 5, just like the unit-type CATV trunk amplifier 4 (or CATV extender amplifier 4') shown in Fig. 2, the number of filters passing the upward H signal can be reduced in half compared to that used in the conventional amplifier, and thus, the same effect as the above embodiment can be obtained.

In the upward H amplifier 61, the connection terminal T3 is connected to the input terminal Tin of the bi-directional amplifier 60, and the connection terminal T4 is connected to the output terminal Tout of the bi-directional amplifier 60, so that the downward signal and the upward L signal can be selectively inputted and outputted to the bi-directional amplifier 60 via the LPFs 14, 22, respectively. Furthermore, the alternating current power signals supplied via the transmission line (trunk La) on the center equipment 2 side or on the terminal device side are separated into signals for the bi-directional amplifier 60 and signals for the internal power supply circuit 40' via a pair of choke coils L1 and L2 so that the alternating current power signals can be supplied to each part of the system through the different paths. As a result, compared to the unit-type CATV trunk amplifier 4, shown in Fig. 2, in which the alternating current power signals are separated at one choke coil L and supplied to the power supply circuit 40 common to the amplifying circuits 18, 28, 34, distortion by hum modulation generated in

the whole CATV trunk amplifier 4 can be reduced.

Specifically, in the CATV trunk amplifier 4 shown in Fig. 5, a current corresponding to the power consumption at the upward H amplifying circuit 34 flows to the choke coils L1, and a current corresponding to the power consumption at the downward amplifying circuit 18 and upward L amplifying circuit 28 in the bi-directional amplifier 60 flows to the choke coils L2. Accordingly, the currents corresponding to the power consumption at each of the amplifying circuits do not flow to one choke coil L intensively as is the case with the unit-type CATV trunk amplifier 4 shown in Fig. 2, and thus the amount of current flowing to the choke coils L1, L2 can be reduced and the generation of the distortion by hum modulation is restrained.

Specifically, the unit-type CATV trunk amplifier 4 shown in Fig. 2 and the separate-type CATV trunk amplifier 4 shown in Fig. 5 were experimentally produced in plural, and the distortion by hum modulation per single amplifier 4 was measured. As for the unit-type amplifier, the distortion was between –72.3dB and –71.4dB, and for the separate-type amplifier, between –72.5dB and –72.3dB. When the CATV trunk amplifier 4 is constituted as a separate-type amplifier shown in Fig. 5, the distortion by hum modulation was improved approximately 1dB.

In addition, hum modulation in the whole system changes according to the connection number of amplifiers 4 which receives power supply from the common power unit 10 and the

position in which the alternating current power signals are supplied. When eight CATV trunk amplifiers 4 were cascaded, and power was supplied from the common power unit 10 at the central connection point to each of the amplifiers 4, the hum modulation in the whole system was measured. The hum modulation in case of using a unit-type amplifier for each of the amplifiers 4 was –57.8dB, and that in case of using a separate-type amplifier for each of the amplifiers 4 was –58.8dB. The hum modulation in the whole system was also improved approximately 1dB.

The hum modulation HM is deteriorated according to an equation "HM = 15 · log (m)", and the separate-type CATV trunk amplifier 4 can improve the hum modulation approximately 1dB compared to the unit-type amplifier. Thus, a ratio of number of the CATV trunk amplifiers 4 capable of being added when a bi-directional CATV system is constituted using the separate-type CATV trunk amplifiers 4, is indicated as (m) = 1.17. If the CATV trunk amplifier 4 used in the bi-directional CATV system is changed to the separate-type amplifier shown in Fig. 5 from the unit-type amplifier shown in Fig. 2, the hum modulation in the whole bi-directional CATV system, in which 16 CATV trunk amplifiers 4 are cascaded, can be improved even though two more CATV trunk amplifiers 4 (16 amplifiers multiplied by (1.17 − 1) = 2.75) are further added to the system.

Accordingly, if a bi-directional CATV system is

constituted using the separate-type CATV trunk amplifier 4 (or CATV extender amplifier 4') shown in Fig. 5, the number of the CATV trunk amplifiers 4 (or CATV extender amplifiers 4') can be further increased and the scale of the system can also be enlarged, compared to the case of using the unit-type CATV trunk amplifier 4 (CATV extender amplifier 4') shown in Fig. 2.

Additionally, when the separate-type CATV trunk amplifiers 4 (or CATV extender amplifiers 4') shown in Fig. 5 are cascaded on the trunk La (or the first branch lines Lb) to constitute a bi-directional CATV system, as shown in Fig. 6, for example, the output terminal T2 and the connection terminal T4 of the upward H amplifier 61 constituting the CATV trunk amplifier 4 at the eighth stage from the center equipment 2 side, and the connection terminal T3 of the upward H amplifier 61 constituting the CATV trunk amplifier 4 at the next (ninth) stage may be respectively terminated at terminal resistance R corresponding to the characteristic impedance of the coaxial cable constituting the trunk La. Then, the output terminal Tout of the bi-directional amplifier 60 at the eighth stage and the input terminal Tin of the bi-directional amplifier 60 at the ninth stage, to each of which an upward H amplifier 61 is externally attached, may be connected by the coaxial cable constituting the trunk La. The input terminal T1 of the upward H amplifier 61 at the ninth stage may be further connected to an electrical/optical converter (E/O) 84 converting electrical signal

to optical signal, and this electrical/optical converter 84 may be connected to an optical/electrical converter (O/E; converter converting optical signal to electrical signal) 82 provided on the center equipment 2 side via an optical cable Lo.

In this manner, the upward H signal transmitted via the amplifiers (CATV trunk amplifiers 4 at the tenth to sixteenth stage in the Fig. 6) located closer to the terminal device than the CATV trunk amplifier 4 at the ninth stage can be transmitted directly to the center equipment 2 via the electrical/optical converter (E/O) 84, optical cable Lo and optical/electrical converter (O/E) 82. Then, it is possible to reduce confluent noises transmitted to the center equipment 2, synthesized on the transmission line by noises in a transmission frequency band of the upward H signal generated at each of subscriber terminal devices, and to improve the accuracy of receiving the upward H signal on the center equipment 2.

In the bi-directional CATV system shown in Fig. 6, the separate-type CATV trunk amplifiers 4 comprising only the bi-directional amplifier 60 and upward H amplifier 61 are arranged on the transmission line (trunk La). However, when a bi-directional CATV system is built in practice, the separate-type CATV trunk amplifiers 4 and other amplifiers (such as unit-type CATV trunk amplifiers 4, CATV bridger amplifiers 6) may be arranged in combination.

While one embodiment of the present invention has been

herein disclosed, the invention should not be limited to the described embodiment, and other modifications and variations might be possible.

For instance, in the separate-type CATV trunk amplifier 4 shown in Fig. 5, the power separating filters 62, 64, in the upward H amplifier 61, for supplying the alternating current power signals inputted from the input terminal T1 or the output terminal T2 to the internal power supply circuit 40' and the external bi-directional amplifier 60, respectively, are constituted of a pair of choke coils L1, L2 and condensers C1, C2. However, since the HPFs 36, 32 connecting the input and output terminals T1, T2 and the internal upward H amplifying circuit 34 are generally provided with condensers arranged in series on the passing path of the signals, it is possible to cut off the alternating current power signals by themselves. On the contrary, the LPFs 14, 22 are provided with coils connected in series on the passing path of the signals so as to cut off the signals with frequencies higher than the cutoff frequency and to pass the signals with frequencies lower than the cutoff frequency, and the alternating current power signals can pass through the LPFs 14, 22 since condensers are generally not connected in series on the passing path of the signals. Therefore, it is possible to use the HPFs 36, 32 as the condensers C1, C2 for cutting off the alternating current power signals so that the condensers C1, C2 can be removed from the upward H amplifier

61, and to use the LPFs 14, 22 as the choke coils L2 for supplying the alternating current power signals to the bi-directional amplifier 60, so that the choke coils L2 can be removed from the upward H amplifier 61.

In this manner, it is not necessary to provide a pair of exclusive filter circuits comprising the condensers C1, C2 and the choke coils L1, L2, and the constitution of the upward H amplifier 61 can be simplified.